IB Docket No. 16-408

THE DIRECTOR GENERAL

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Accepted / Filed

SEP 15 2017

Federal Communications Commission
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VIA ELECTRONIC FILING

Ms Marlene H. Dortch
Secretary
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Washington, D.C. 20554

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DG/321

Paris, 30 August 2017

Subject: Comments of the European Space Agency in IB Docket No. 16-408

Dear Ms Dortch,

In its role as THE European Space Agency, ESA, works towards ensuring autonomy in accessing and using space. This entails safeguarding space as a shared, natural resource and environment. In this context, accurate implementation of space debris mitigation is of utmost importance. For this reason, we would like to share with the Federal Communications Commission, in support of its efforts to ensure that space is protected by reasonable regulations and responsible operations, some of the considerations that we have made. These considerations guide our present and future efforts and activities and we believe them to be even more important in view of the latest innovations in non-geostationary satellite technology and developments and announcements in the field of megaconstellations.

Firstly, we would like to recall existing space debris mitigation guidelines as the fundament of our considerations. In 2002, the Inter-Agency Space Debris Coordination Committee (IADC) drafted a set of guidelines for international space debris mitigation, aimed at limiting the generation of debris in the environment in the short-term, through measures typically related to spacecraft design and operation, and the growth of the debris population over the longer-term, by limiting time spent in the LEO region after the end of mission to 25 years.

Based on the work of the IADC, guidelines on UN-level have been developed and endorsed by the UN General Assembly in its resolution 62/217, dated 1 February 2008 and entitled "International cooperation in the peaceful uses of outer space". These mitigation guidelines are also reflected in the ISO-24113 standard "Space Systems - Space Debris Mitigation".

We strongly recommend to make these mitigation guidelines applicable, as they have been demonstrated to be suitable to preserve the LEO environment in the short-, mid- and long-term. A direct consequence of this is the absence of graveyard orbits. Most proposed concepts for large constellations in LEO target operational altitudes above 1000km.

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This is far higher than the average space traffic into LEO. It is well known that average natural atmospheric drag induced orbital lifetimes (from end of mission to natural atmospheric re-entry) increase exponentially with altitude. For typical spacecraft, above 1000km, these average orbital lifetimes are quasi eternal. Therefore, active disposal (propulsive) comes into the prime focus for such missions.

The guidelines presented above have been formulated with the average space-traffic in mind. They have not been tested for robustness in view of a scenario of a step increase in spaceflight activities, such as by large constellations. They also have no special provisions for the practicalities of such constellations.

Further, the guidelines do not come with success criteria reflecting the tolerable likelihood of technical failures. Studies have shown that today's success rate in implementing post mission disposal in LEO is limited to only 60% of the missions. The reasons for this is partly the fact that not all currently flying missions have been developed under the regime of the guidelines yet. However, it is also evident that is also due to technical failures. Studies have also shown that negative environmental consequences of failures to implement guidelines are significantly more severe compared to the average space traffic, solely driven by the large numbers and the comparably high altitudes involved. This puts significant responsibility on a very limited number of space actors. While the guidelines remain valid and functional, the efforts required by the large constellations are extremely high.

Therefore, we would like to provide recommendations shaped specifically for large constellations, providing technical guidance on how to best adhere to the existing guidelines:

Constellation Design

- Low operational orbit altitudes should be considered. Average orbit altitudes < 650km for average satellites < 1ton are normally still compatible with a natural decay within 25 years. Average orbit altitude > 800km: require extremely reliable post-mission disposal reliability. Break-ups have long-term and environmental trend-changing effects
- Altitude separation w.r.t. other large constellations and already used shells should be considered
- A minimisation of the number of spacecraft required (incl. spares) should be envisaged. There is an exponential relationship between environmental effect and the number of failed spacecraft. This has also direct implications for the workload connected with collision avoidance
- Replenishment spacecraft should be injected into orbits < 650km, such that all injected objects follow a 25year decay time in case of failure. Spacecraft should then move to their operational altitude only after a complete and successful functional check-out
- Within a constellation altitude, separations at intersection points between intersecting orbital planes of a constellation should be considered.

Spacecraft Design

- A post-mission disposal reliability of virtually 100% is required for operational altitudes > 650km in particular in the presence of additional large constellations. This reliability is to be provided: by design through internal multiple redundancies of all functions involved in the post mission disposal, by regular monitoring of the availability of the post mission disposal function and initial disposal action as soon as availability drops, even if design lifetime is not reached, and by the use of independent de-orbiting devices that work on independent power supply and automatically initiate disposal after loss of contact
- The risk on-ground upon re-entry should be limited by controlled re-entry or by optimisation of spacecraft design that favours demise and limits fragment generation during re-entry (though constellation spacecraft are typically small, and the risk per spacecraft is moderate, the accumulated risk might well overshoot the on-ground risk of the remaining space traffic)
- The robustness of the spacecraft design to the space environment should be tested with a low number of satellites in the final environment for > 5 years before the whole series is launched (Often, critical components inducing break-ups are identified only after years of operation. For large constellations, this might result into large problems due to the large series and the short production times. It might, hence, turn out that the first of such unexpected failures occurs after the whole of the series is launched, and design retrofit in no longer possible.)
- Solutions should be explored that enable independent and automatic passivation after loss of power/contact
- The trackability by active means from ground should be enhanced. A better trackability, achieved by an increased radar cross section (RCS) or by the presence of a laser retroreflector, can improve the orbit covariances and shorten the track lengths per pass. This would have a positive impact on the number of conjunction false alerts.

Operations

- Launcher stages should exhibit the same perfect (close to 100%) post mission disposal and passivation reliability as the constellation spacecraft
- Immediate and controlled re-entry for the upper-stages is recommended. Upper stages delivering spacecraft into altitude > 800km often have dry masses > 1ton, which typically raises on-ground safety issues
- Spacecraft should be equipped with the means to conduct agile collision avoidance manoeuvres. A reasonably sized on-call team should be available for the management of the expected high number of conjunctions. Automated processes should be considered. Manoeuvre plans should be openly communicated
- Spacecraft disposal by orbit raising (to > 2000km) should be avoided, in line with the current IADC guidelines (this would lead to the inset of collisional cascading at altitudes above 2000km, with also negative effects to lower altitudes)
- Disposal on orbits with orbital lifetime much shorter than 25 years reduces operational burdens for spacefarers in lower orbital regimes
- For circular disposal orbits, an altitude variability should be applied to avoid peak densities below 650km

- For eccentric disposal orbit, the apogee should clear the operational altitude at the epoch of disposal and the perigee should be selected applying an altitude variation.

We remain available to discuss these matters at greater length at your convenience. The leadership of the Federal Communications Commission in managing space debris is essential for the protection of the orbital environment, and the safety of individuals and property in space and on the ground. We look forward to a close cooperation to guarantee the safety of space.

Yours sincerely,

Johann-Dietrich Wörner

Cc:
Anne E. Sweet
NASA Representative on the Commercial Space Transportation Interagency Group Program Executive, Launch Services Office
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